



# Time-Series Analysis: A Cautionary Tale

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# What is time-series analysis?



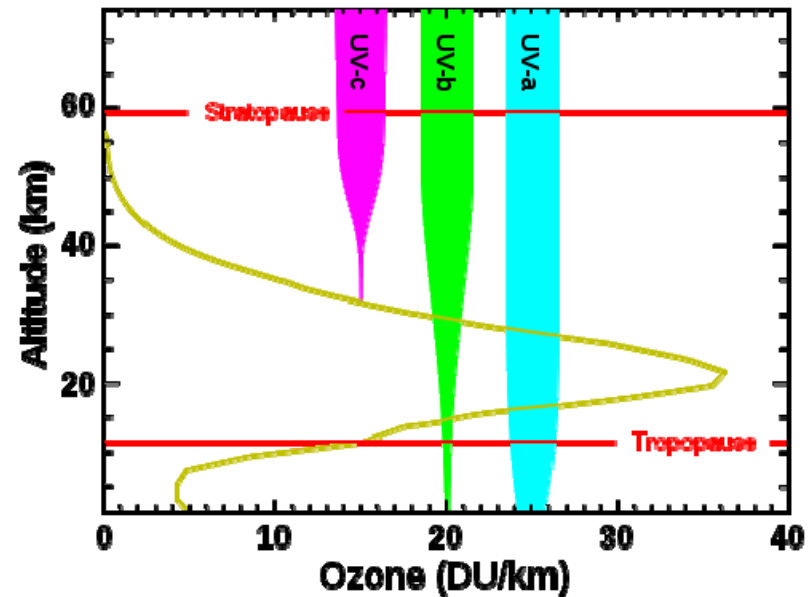
- Useful tool for analysis of long-term data
- Lots of math and statistics
- Common pitfalls (bad assumptions)
- Practical example: Derivation of long-term trends in stratospheric ozone



# Ozone is Important



- Earth's "sunscreen"
- Destruction from CFCs (and other man-made compounds containing Cl and Br)
- Montreal Protocol (1987)
- Is it recovering?

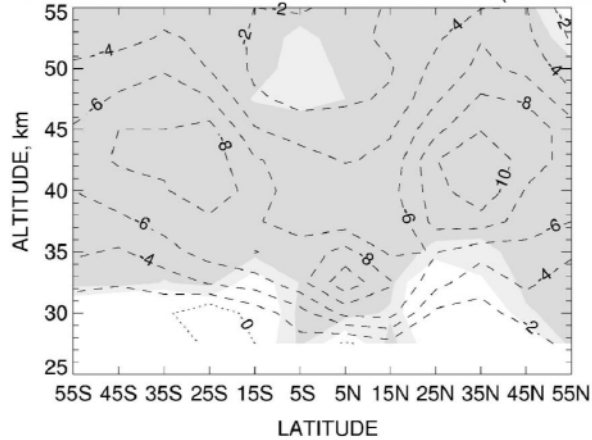




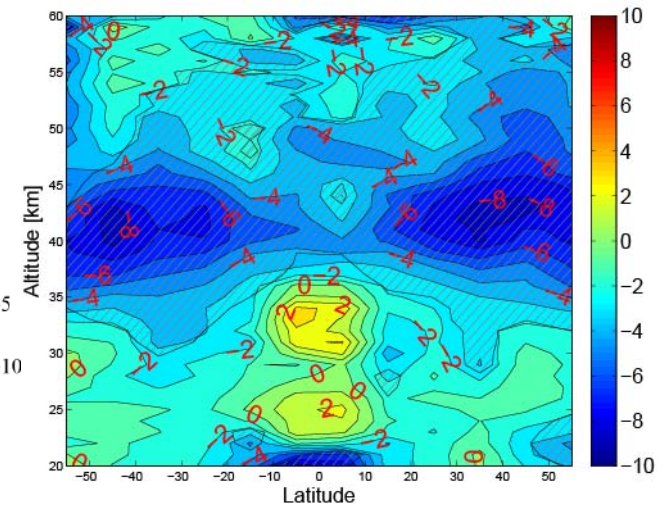
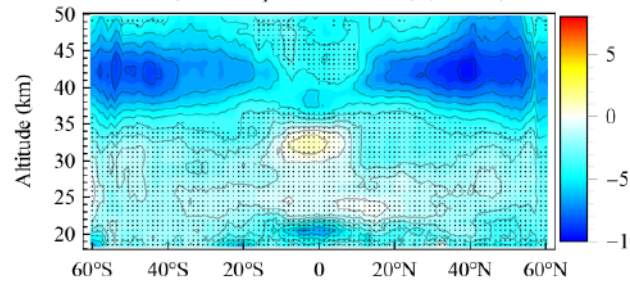
# How has it changed?



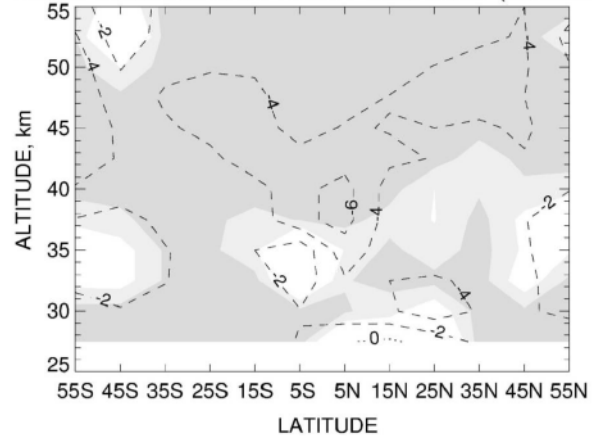
Linear Trends in SAGE O3 v7 from 84/98 (%/decade)



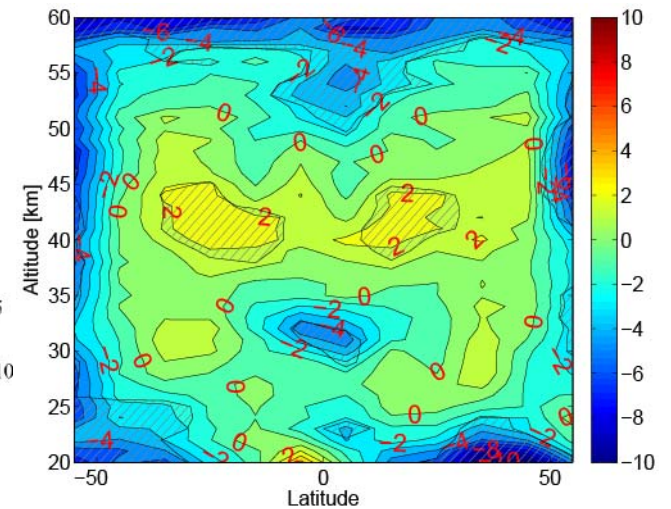
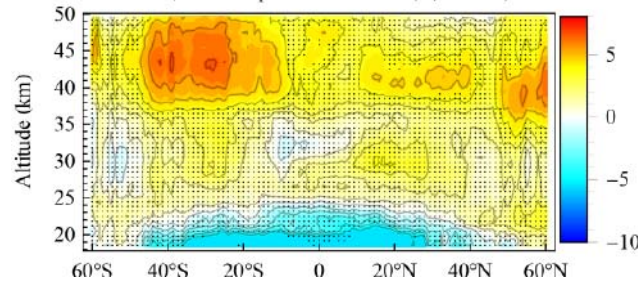
SAGE II / OSIRIS pre-1997 trend (%/decade)



Linear Trends in SAGE O3 v7 from 91/05 (%/decade)



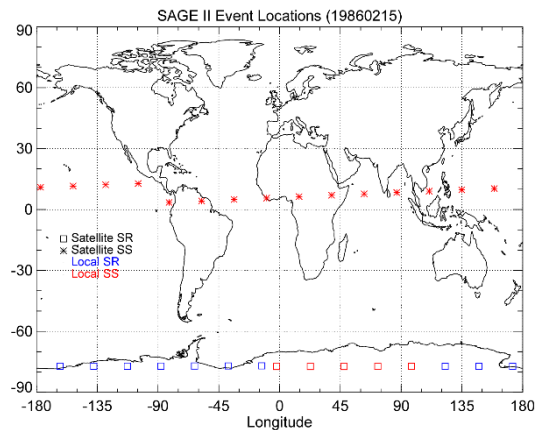
SAGE II / OSIRIS post-1997 trend (%/decade)



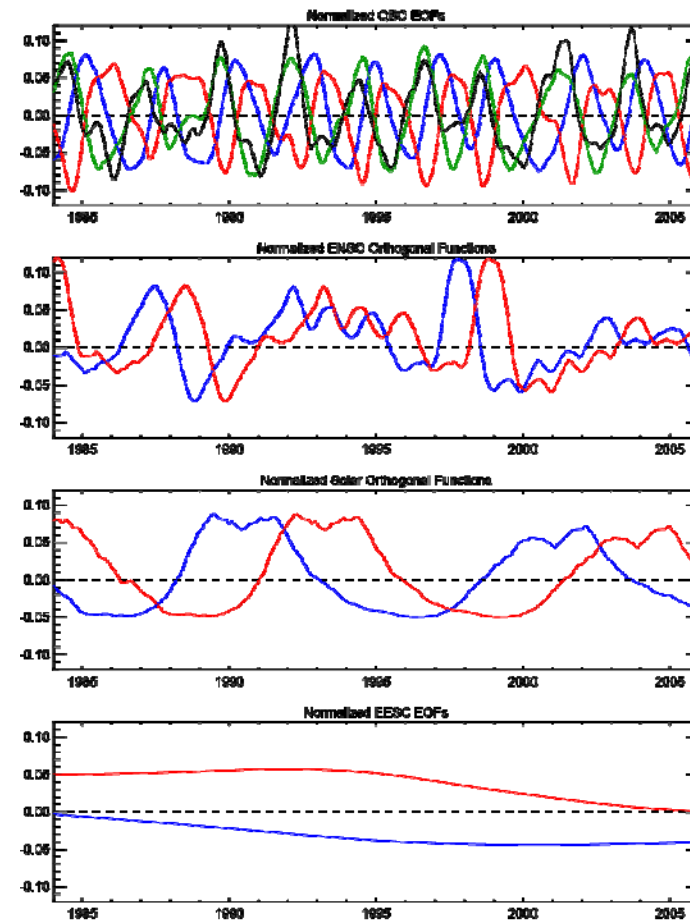


# Methodology

- Data Resolution

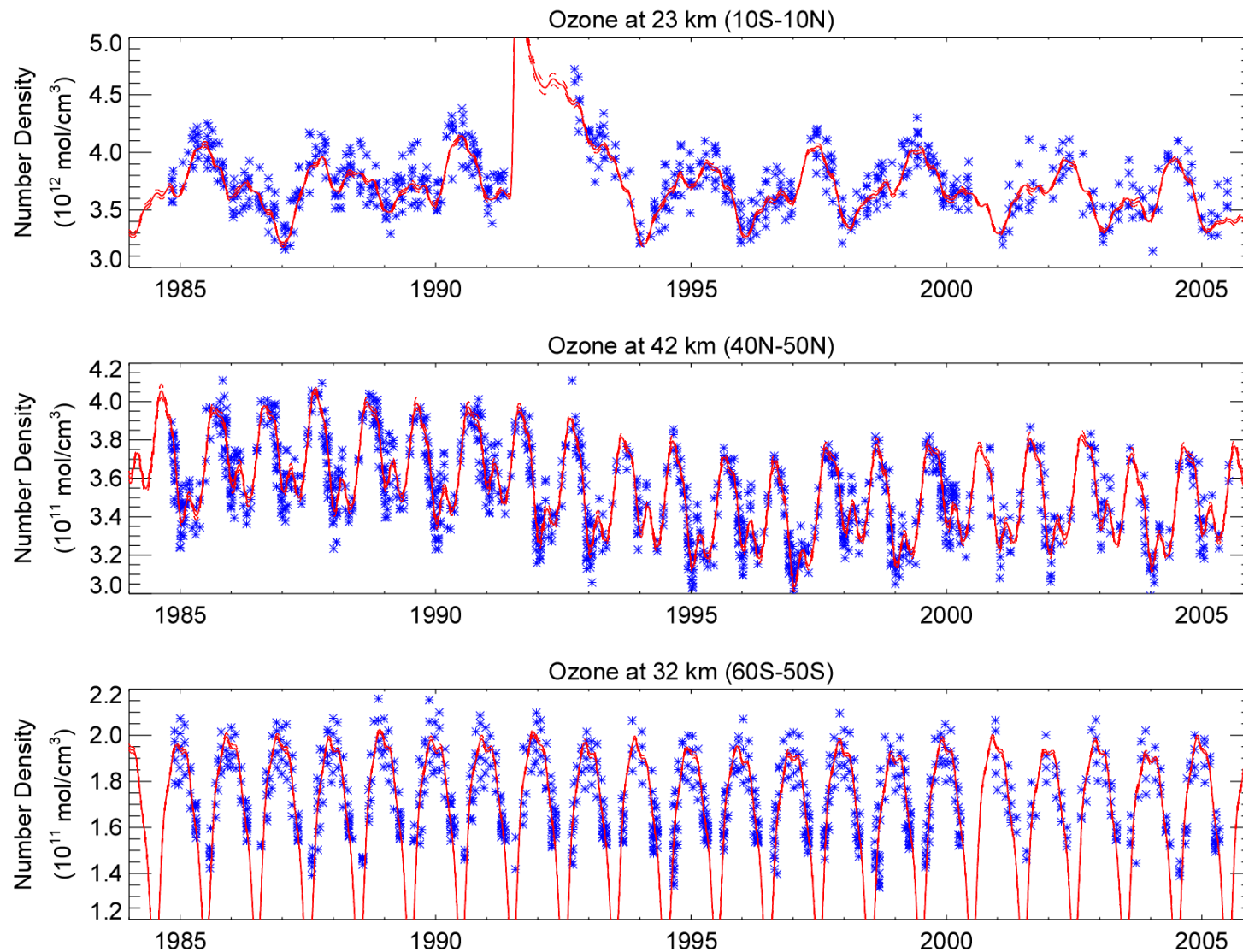


- Regression Model
  - Choosing Predictor Variables
  - Orthogonal Function Analysis
- Multiple Linear Regression
  - Autocorrelation
  - Heteroscedasticity
- Residual Filtering
- Coefficient Filtering





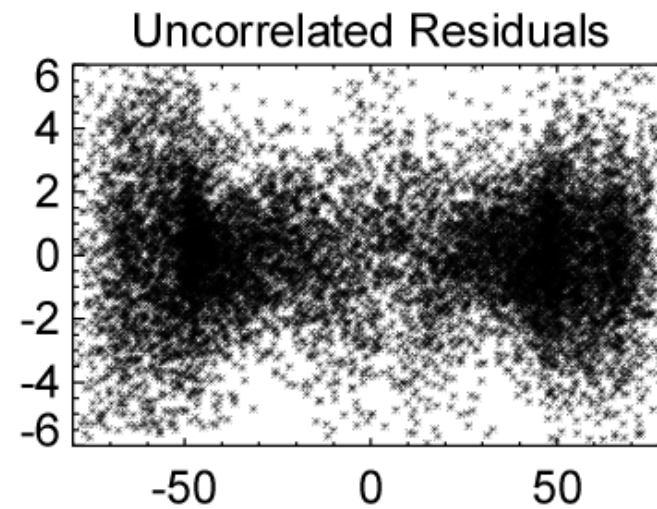
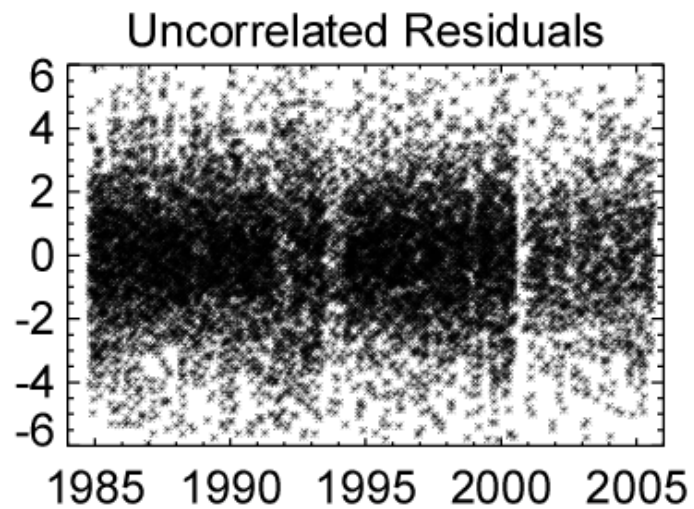
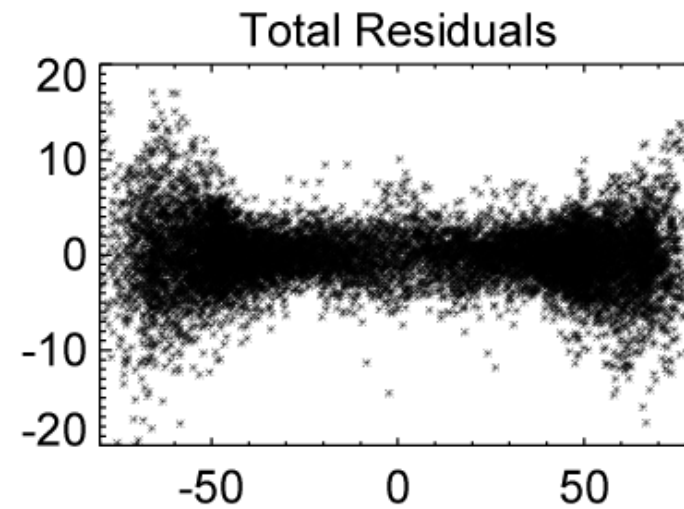
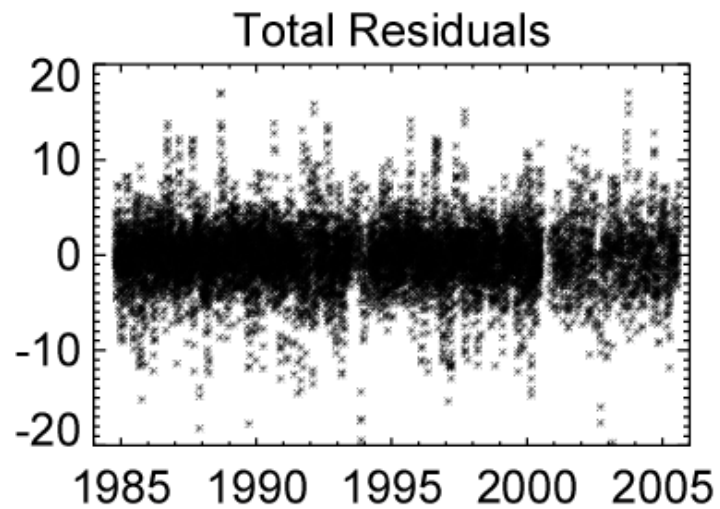
# Check your fits ...





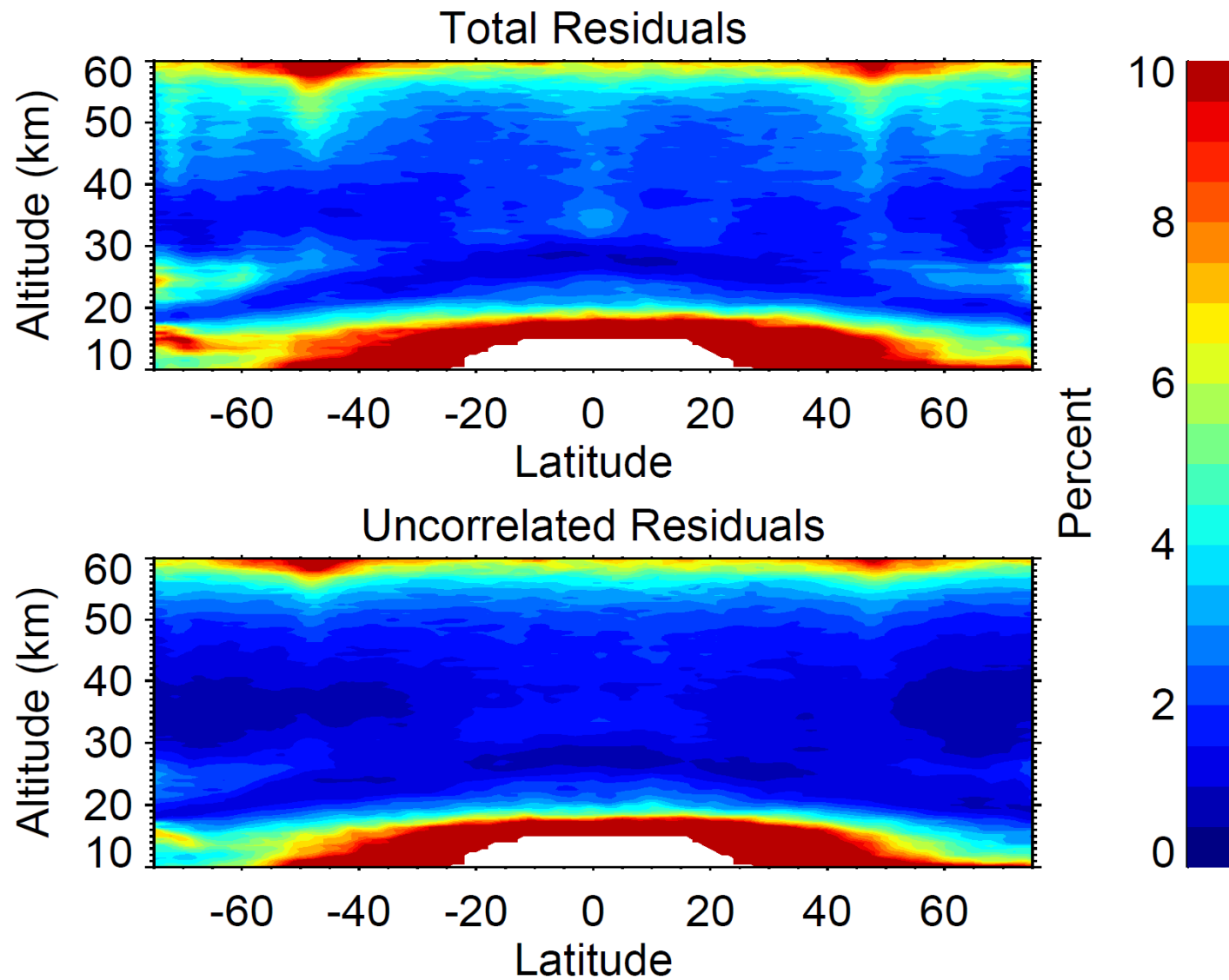


... and your residuals





# Residuals Matter



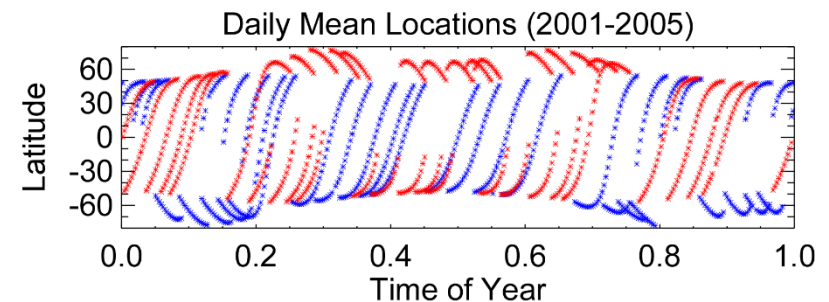
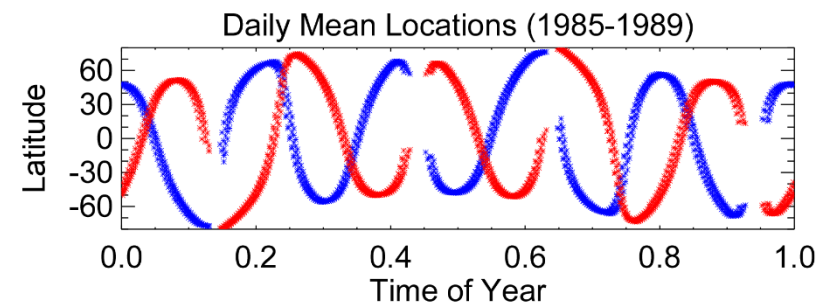
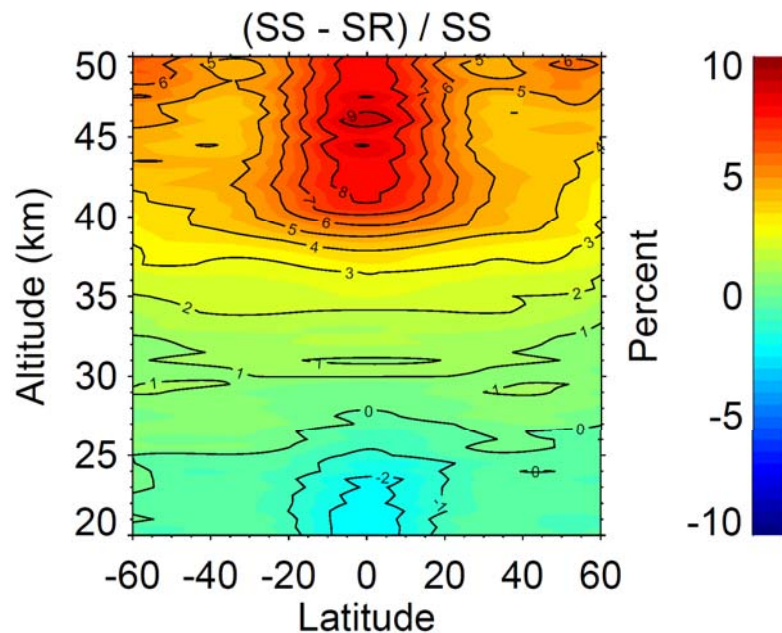




# Sampling is Critical!



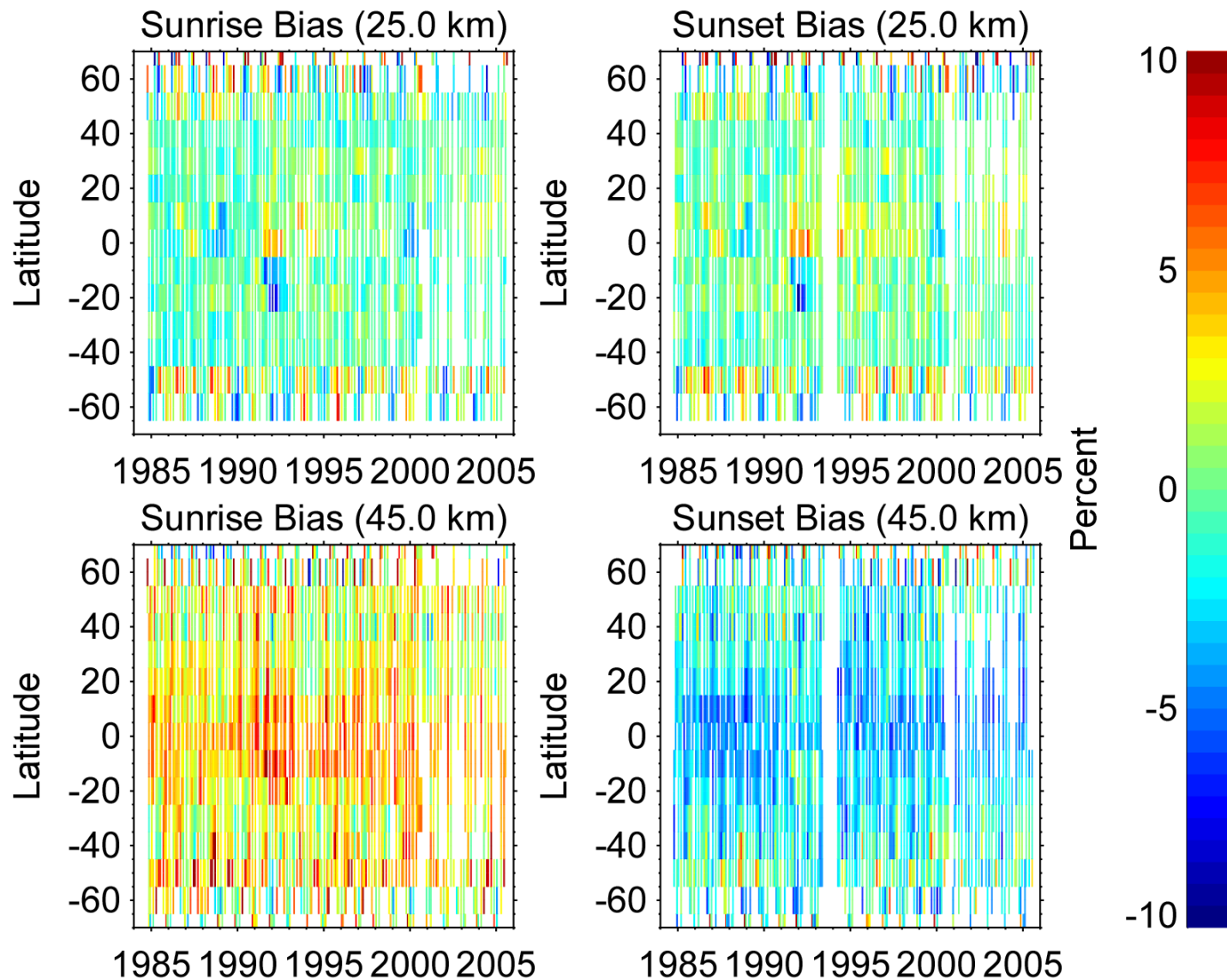
- SAGE observes the same latitude at the same times during the year
- Orbital degradation increases precession and causing a drift in sampling



- Diurnal variability (geophysical or algorithmic) is important at higher altitudes

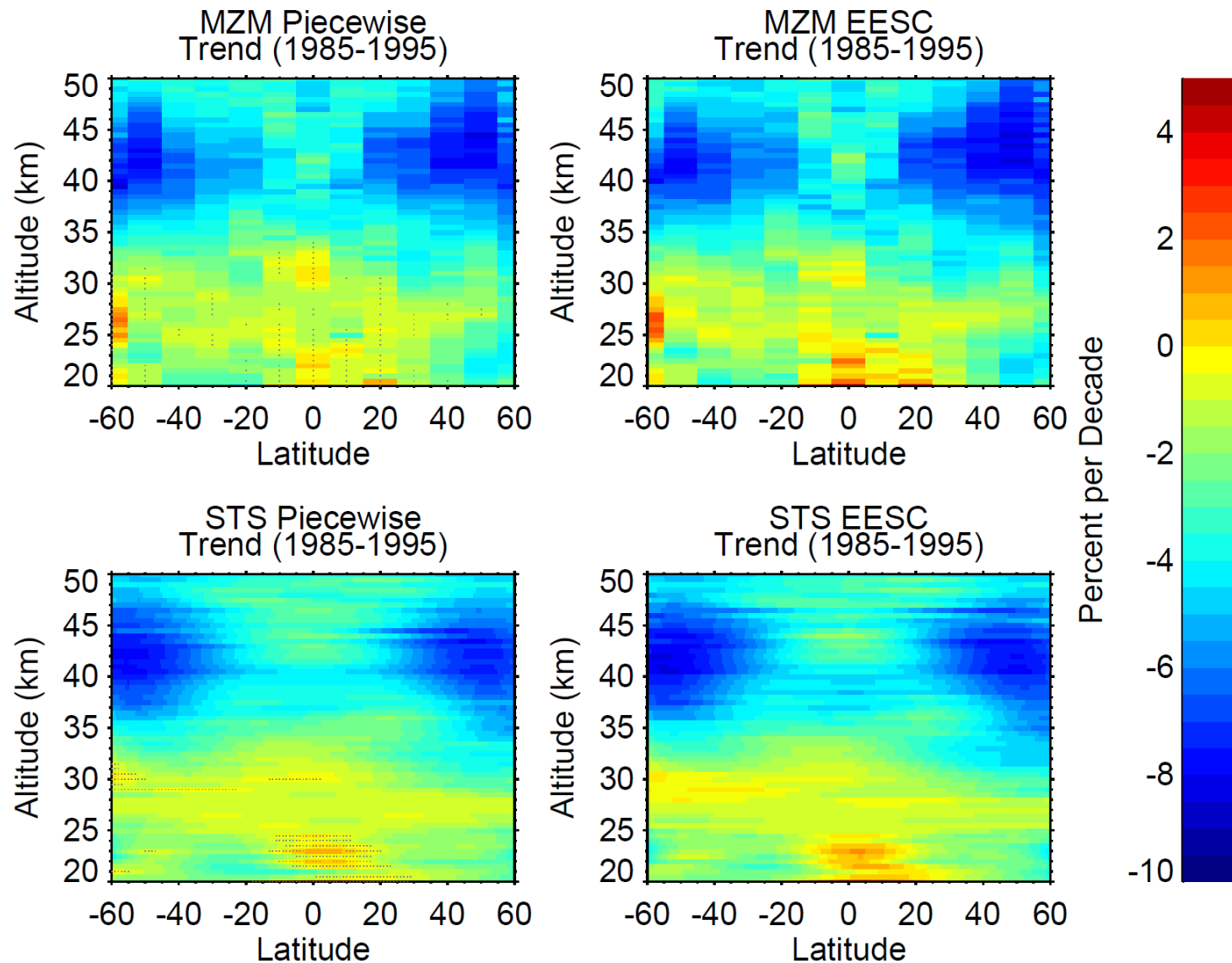


# Sampling Induced Biases



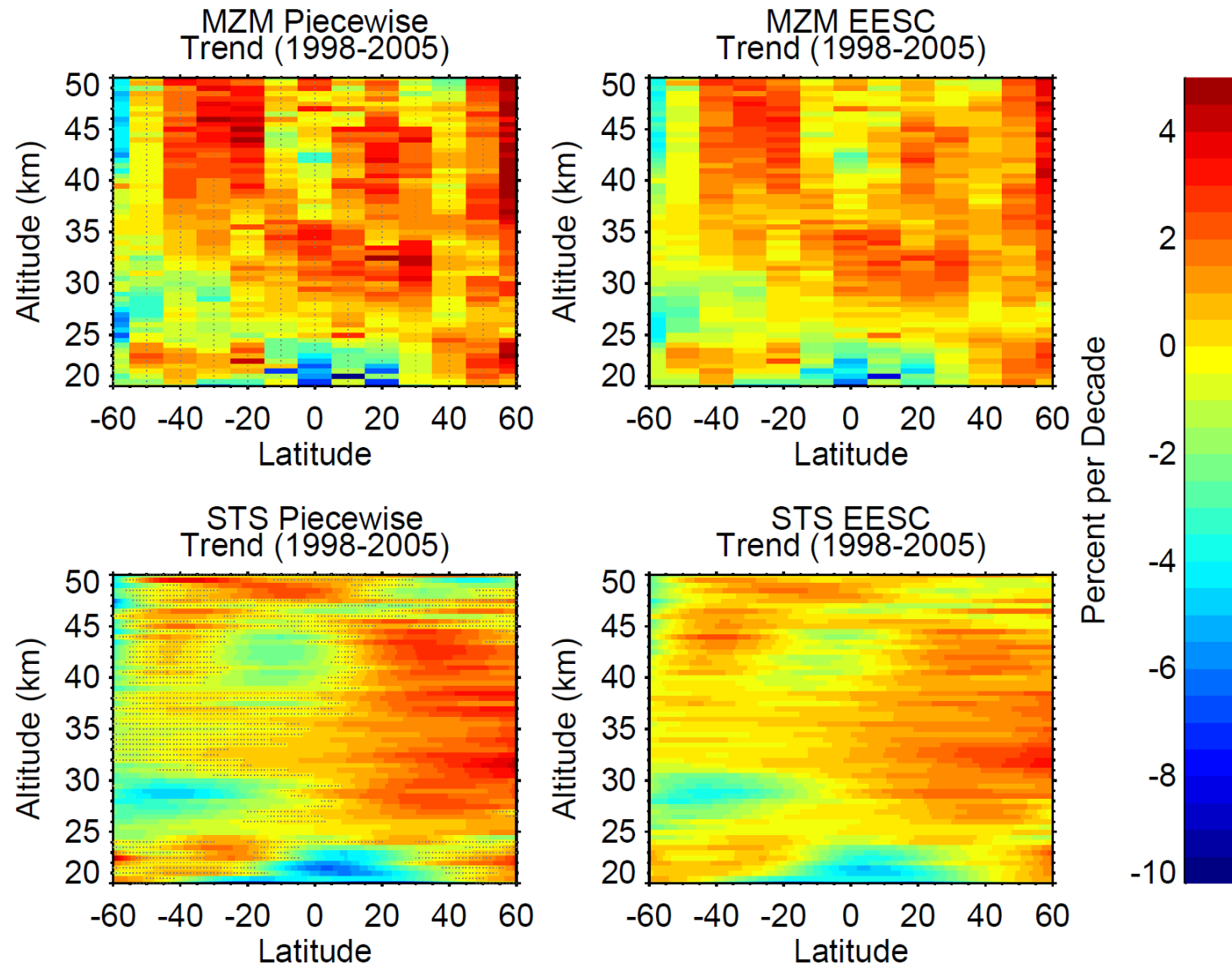


# Trend Comparisons (Decline)



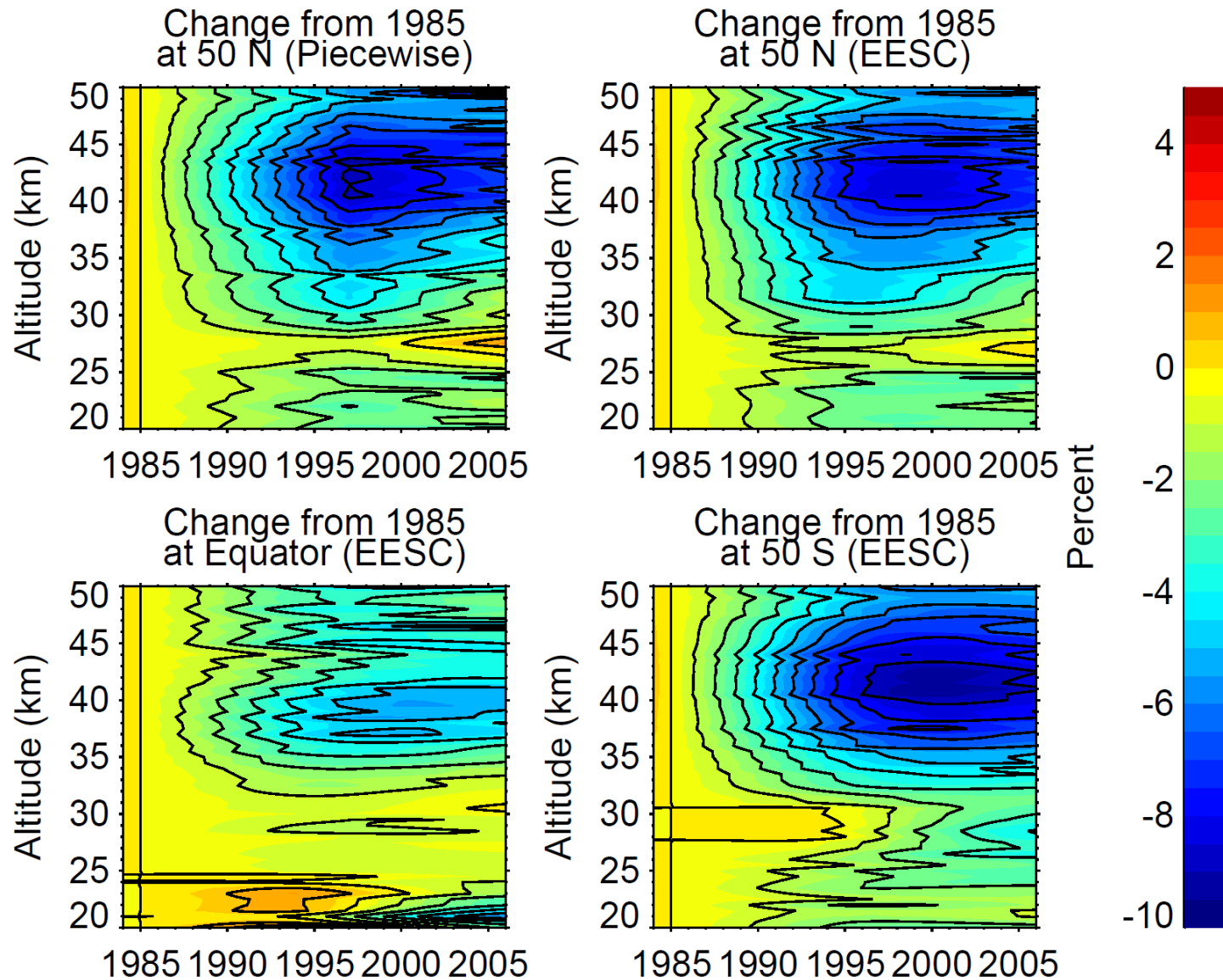


# Trend Comparisons (Recovery)



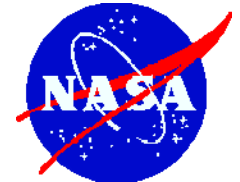


# Linear Trend or EESC?





# Conclusions

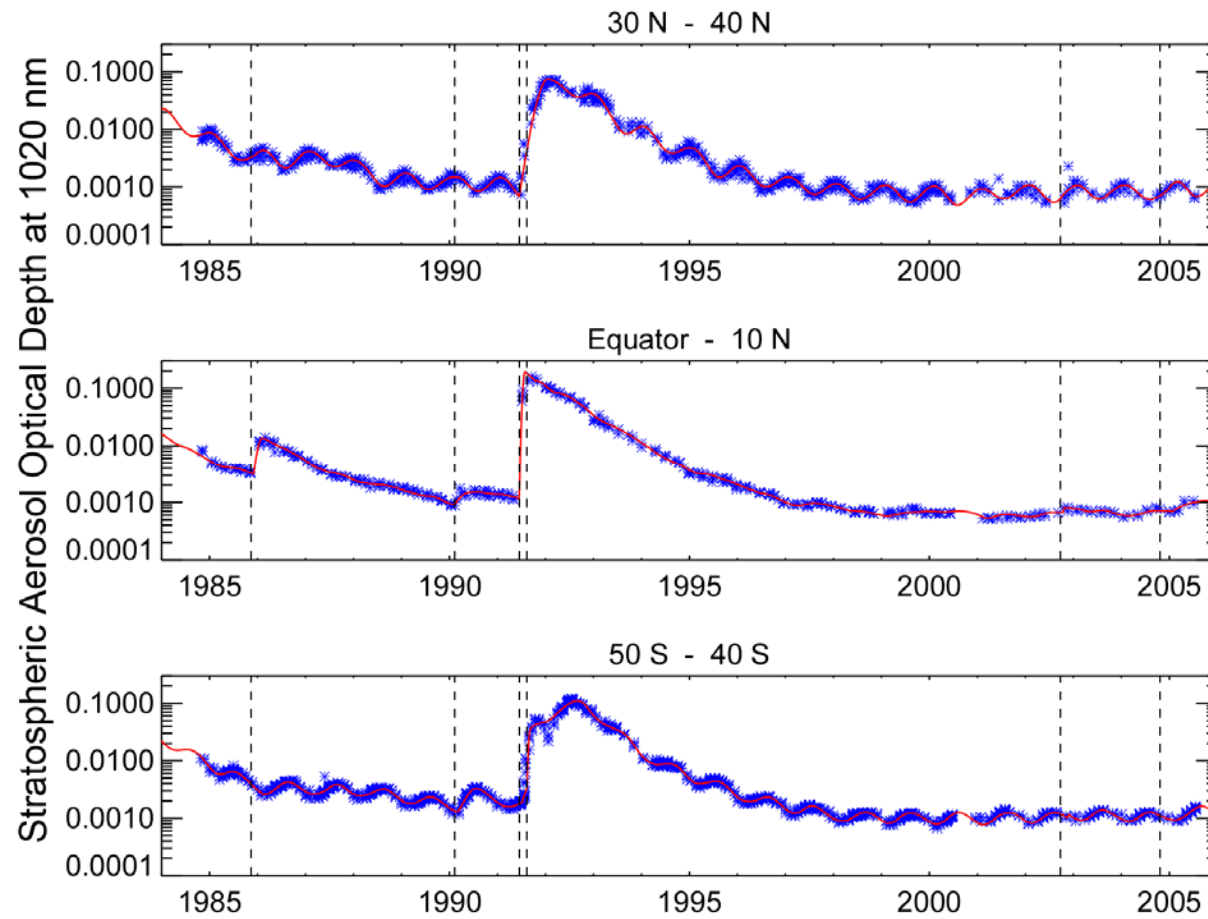


- Know your limitations! (watch out for pitfalls)
  - Can mitigate biases introduced by non-uniform sampling
  - Reproduce others' work before doing something new
  - Don't be afraid to challenge the scientific community
- 
- Want to know more?
    - <http://www.atmos-chem-phys.net/14/13455/2014/acp-14-13455-2014.html>

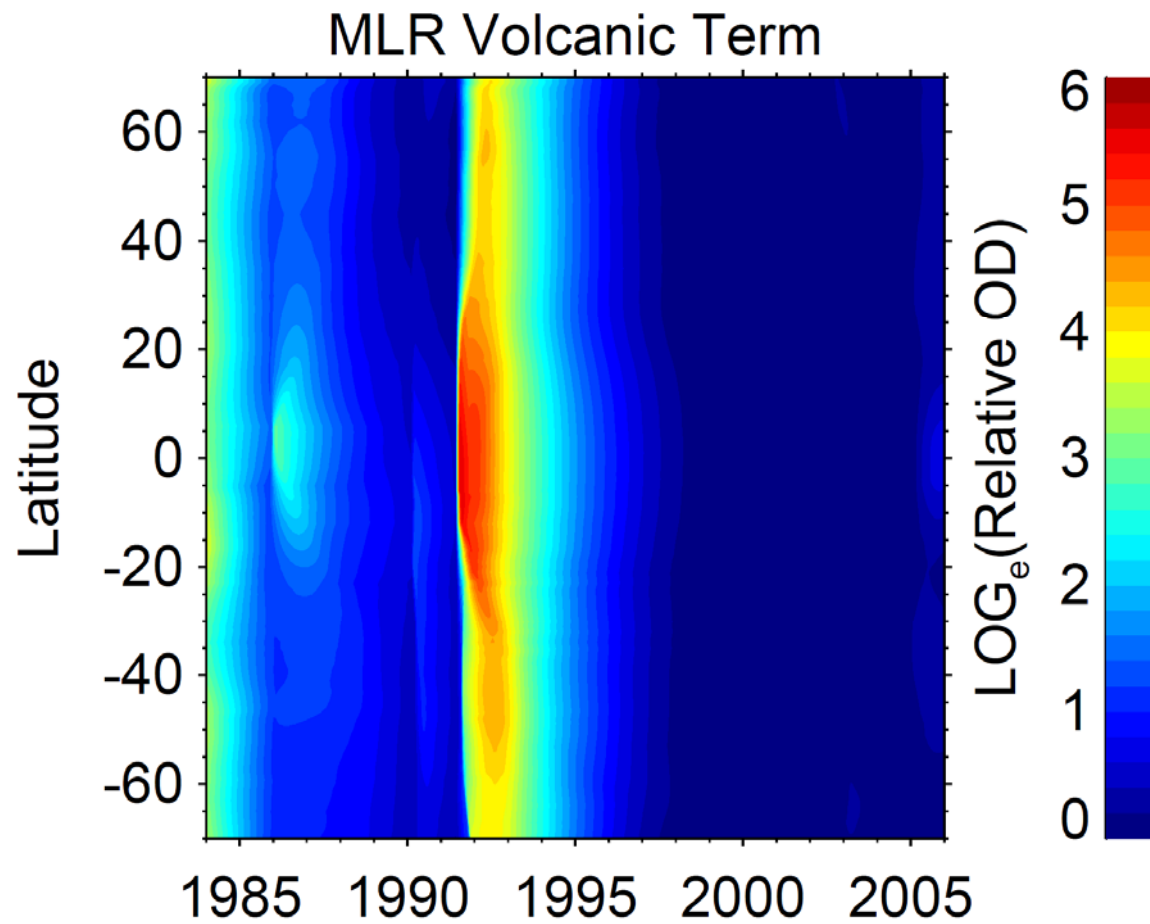


# Extra Slides

# Creation of volcanic proxy



# Final volcanic proxy



# Result from regression

